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Structure and Function of the Environmental Industry: the Hidden Contribution to Sustainable Growth in Europe

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creating sustainable growth in europe

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The hidden Contribution to Sustainable Growth in Europe

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ffu

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Content

Abstract

The paper shows the results of a study, which the Environmental Policy Research Centre conducted in the context of the international research project: "Resource productivity, environmental tax reform and sustainable growth in Europe" (PETRE).[1] PETRE is part of the Anglo-German Foundation research policy initiative: Creating sustainable growth in Europe.[2]

The study focuses on the "eco-industry", their function, structure and dynamics in Germany and for Europe. It describes two faces of environmental industry: a more traditional part of end-of-pipe treatment or "pollution management" and the newer, fast growing part of eco-efficiency or "resource management". The study gives a general explanation to this rapid growth. For many reasons eco-efficient innovation is a necessary condition for sustainable industrial growth. The authors come to the conclusion that this industry so far has been underestimated – not least because its dynamic creates big problems as regards statistical definitions. To a large extent this is an "invisible industry". In a second step an explorative analysis of the German environmental industry – the most advanced case in Europe – is done. Four selected parts of the environmental industry are analysed together with the related policies and instruments: Green power, eco construction (low energy buildings), fuel-efficient diesel cars and industrial recycling. The description of co-benefits includes higher employment, innovation and successful export. The explorative study shows the high importance of economic instruments in combination with regulation. The price increase of energy and raw materials plausibly has been important too. However, it cannot explain the specifics of the German success case.

1 see http://www.petre.org.uk/papers.htm.

2 see http://www.agf.org.uk/currentprogramme/CreatingSustainableGrowthInEurope.php

Zusammenfassung

Der im wesentlichen explorative Beitrag untersucht die Rolle der “Umweltindustrie” in der EU am Beispiel des Pionierfalls Deutschland. Dabei werden vier Felder erfolgreicher umweltpolitischer Steuerung exemplarisch dargestellt. Im Ergebnis zeigt sich zunächst das doppelte Gesicht dieses Sektors: Anbieter nachgeschalteter Umwelttechnik (end pof pipe) bilden den kleineren, eher stagnierenden Teil dieses „Sektors“. Die Bedeutung der „Umweltindustrie“ zeigt sich dagegen in dem raschen Wachstum bei den öko-effizienten, also zugleich Ressourcen schonenden Technologien. Die Dynamik dieses Technologiebereichs, der typischerweise auch einen positiven Beitrag zur Produktivitätsentwicklung leistet, macht die Potenziale von „Sustainable Growth“ exemplarisch deutlich. Der Beitrag zeigt zugleich, dass die Größe der „Umweltindustrie“ deutlich unterschätzt wird und die statistisch bezifferbaren Beiträge erheblich übersteigt. Allein der Klimaschutz hat in Deutschland Investitionen in der Größe von 5% des BIP ausgelöst (2005). Die Erfassungsprobleme sind kein Zufall: Der um sich greifende breite Trend zur Steigerung von Öko-effizienz (mainstreaming) kommt oft nur innerhalb der Unternehmen selbst zur Geltung. Und ob ein Produkt „öko-effizient“ ist, hängt von Definitionen ab, die im Prozess der Modernisierung wiederum ihre Bedeutung verändern können.

In den vier Fallbeispielen werden Steuerungsmechanismen untersucht, die öko-effiziente Technologien begünstigen. Dabei wirken in den letzten Jahren naturgemäß auch die gestiegenen Energie- und Rohstoffpreise. Dies erklärt jedoch nicht die Unterschiede bei dem untersuchten deutschen Fall von Best practice. Das starke Wachstum öko-effizienter Technologien ist offensichtlich politikabhängig (policy-driven). Dabei zeigt sich eine starke allgemeine Bedeutung des Preismechanismus in Verbindung mit spezifischen regulativen Maßnahmen. Der monetäre Mechanismus der Öko-Steuer hat bei der Energieeinsparung von Gebäuden und bei energiesparenden Dieselmotoren offenbar eine höhere Bedeutung gehabt. Bei erneuerbaren Energien hatte das Instrument der Einspeisevergütung die größte Bedeutung. Regulative Maßnahmen standen im Bereich des industriellen Recycling (neben dem Anstieg der Rohstoffpreise) im Vordergrund. Ergänzende Instrumente (die KfZ-Steuer oder Markteinführungshilfen) spielten im Policy mix ebenfalls eine Rolle. Neben den intendierten Umwelteffekten zeigen sich auffällig klare Win-win-Vorteile in allen vier Fällen: Beschäftigungseffekte, Innovationen und Exportvorteile. Insoweit ist der deutsche Fall von Best practice zugleich ein wirtschaftlicher Erfolgsfall, der auf aktiver Umweltpolitik beruht.

1 Introduction - The New Face of the Environmental Industry

This chapter tries to clarify the definition, structure, function and trend of the "eco-industry" – now an important sector contributing to sustainable growth in Europe (Ayres / van den Bergh 2005). Its potential for multiple win-win effects will be illustrated in four "best practice" case studies. The chapter includes concepts to define eco-industry and an outline of future trends.

The "Environmental Industry" (EI) has until now been an essentially "invisible industry" in terms of statistics and sectoral analysis. The size depends on the definition, while different approaches seem to be available.

To get a clearer picture we differentiate between two sub-sectors: pollution management and resource management. Another differentiation is between a statistically better operationalised core area like waste management and satellite areas such as "eco-tourism" or "eco-construction" (e.g. where only growth rates of components are available).

The statistical defined part of environmental industry is a fast-growing quasi sector of at least 2.6% GDP in the EU and at least 4% in Germany. This Industry however is being necessarily underestimated in terms of existing statistics. The German case shows that investment in climate-friendly technologies alone amounts to 5% of the GDP (2005). Beyond statistics, the high importance of EI can be shown in terms of functional analysis: The activity of the eco-industry – especially regarding eco-efficient innovations - is a *condition* for sustainable growth because it prevents externality damage costs which in the long run restrict economic growth. This function creates global markets with a long-term perspective. EI therefore also contributes *directly* to sustainable growth.

The competitiveness of EI can be shown by indicators such as export rates. Whether it is also contributing to the general competitiveness of the national economy is of high interest, but so far difficult to answer.

The environmental industry is essentially policy-driven. Therefore questions of governance play an important role. To assess the impact of environmental policy on economic success variables we will focus on selected cases: renewable energy, eco-construction, fuel-efficient diesel cars and waste management/recycling. "Policy" in our context does not mean only the use of environmental taxes. Environmental policy - especially if it is oriented towards innovation – typically employs a "multi-impulse approach" (Klemmer 1999). But in light of environmental policy analysis it seems highly plausible that environmental taxes or emission trading - together with specific regulation and supportive instruments like labels or networking - provide the most important political incentive to develop new eco-efficient technologies. It can be shown that within the policy mix in Germany the environmental tax has a relevant impact regarding fuel efficient cars and eco-construction. In case of electricity from renewables there is a clear influence of the change of relative prices (by the feed-in regulation) – together with the rise of prices for fossil energies. In all cases environmental policy is a clear driving force in Germany.

Regarding the environmental impacts of the EI the picture is ambivalent: There are two faces of EI which become visible if we differentiate between the just mentioned sub-class of pollution management - mainly end-of-pipe treatment - and resource management including clean(er) technology. Whereas resource management typically intends to influence resource productivity, pollution control mostly has no such influence - or even a negative one. Therefore EI as such gives no reliable explanation. Pollution management has an important impact on specified pollutants, the impact on resource use here being insignificant or even negative. Efficient resource use, on the other hand, sometimes may have lower impacts on specific pollutants but it has impacts on a broader variety of environmental stress factors: from mining to transport, from waste to dissipative losses of all kinds, which are responsible for physical changes of nature and also emissions.

2 Function, Structure and Dynamics of the Environmental industry

As „Environmental industry" we define (similar to Eurostat and the OECD) the sum of enterprises that produce marketable goods and services both for traditional additive pollution management ("clean-up" or "end-of-pipe-treatment") and integrated resource management or eco-efficient production and consumption.

The differentiation between pollution management and resource management seems plausible and useful (Ernst & Young 2006). But contrary to Ernst & Young and Eurostat we propose to include „clean(er) technology" into the resource management sector (see also DTI/DEFRA 2006). This revised classification would include all "integrated" environmental technologies into the sub-class of resource management. This also would underline the special character of the clean-up/ end-of pipe-type of environmental technology: As a rule it causes not only additional costs, in most cases it leads also to additional resource use (e. g. the lime input for desulphurization, additional electronic equipments or materials for sound-absorbing barriers). Resource management on the other hand means more efficient resource use and thereby also higher productivity (Meyer et al. 2007). Innovations can take place also in the area of pollution management (clean-up technology). Often they are highly effective as far as special pollutants are concerned. Eco-efficient innovations and resource management typically have a broader scope of environmental effects, as well as being more competitive economically.

2.1 The Environmental Industry as Functional Condition of Sustainable Growth

Industrial growth is only possible and sustainable if negative external effects and damage costs are steadily "neutralised" and environmental impacts remain at a constant or decreasing level. This necessitates a permanent reduction of emissions, waste or other negative ecological effects relative to the produced unit of GDP, either by pollution management or resource management. The production and innovation of pollution control technologies and ex ante eco-efficient products or investment goods (including the related services) is so far essentially the function of specialised producers: the environmental industry, which encompasses the green technology division of companies. This quasi sector of the economy, therefore, is the functional prerequisite of sustainable growth. It is a sector producing marketable technical solutions for global environmental needs. The market potential is different from many other products: It is characterised by its global dimensions, a long-term future perspective and a permanent pressure for environmental innovation.

Due to market failures EI is to a high degree policy-driven (Ernst & Young 2006, Jänicke/Jacob 2006). Markets are the most important mechanism to stimulate competitive innovations of clean/cleaner technologies, but their potential comes with qualifications: Markets in general do not have (a) the capability to detect long-term environmental damage, (b) private firms do not have an adequate incentive to develop marketable solutions. Typically markets also are (c) unable to create sufficient demand for such solutions - which need high market penetration to be effective in terms of environmental protection.

Here the constitutional obligations and legitimation mechanisms of democratic government become relevant. The role of public policy is especially important when the pressure for change is high and the rate of technical progress too low (e.g. for climate change). Governments, individually or by concerted action, typically translate environmental threats into regulations. Such policy regulations support the demand for marketable solutions. At the same time they provide standardised information about problems, solutions and the probable reaction of competitors and clients.

The growth of the EI can be primarily explained by this functional necessity of damage prevention which in the past often has manifested itself by ecological crises or political protest (e.g. Japan, USA or Germany). Recent examples are China or Southern Europe. Since the sinks are restricted and the resources are not always available (or characterised by volatile prices) global industrial growth necessitates eco-efficiency at ever higher levels. This causes permanent pressure for environmental innovation (Jänicke 2008). EI, therefore, is not only a fast growing but also a highly innovative sector. According to the British Department of Trade and Industry the EI is highly knowledge-intensive contributing more than average to the added value and productivity of the national economy (DTI/DEFRA 2006, 6). Since EI provides marketable solutions not only for governments but also for enterprises facing the risk of environmental regulation or other kinds of pressure this sector may also have a modernising function for the whole economy.

The first function of the EI is to prevent or reduce environmental damage. But there is also a more constructive function especially in highly developed countries to improve environmental conditions. The growing global middle class is characterised by its higher demand for a healthy and "natural" environment.

So far all this is true only for highly developed countries, which play the role of trend-setters for environmental innovations, thereby creating lead markets for environmental innovations (Jacob et al. 2005, Beise/Rennings 2003). Successful export – starting from leading national markets – may be the most plausible test of whether the growth of the sector has a positive impact on sustainable growth in economic terms.

The special characteristics of EI and eco-efficient innovation – global and future market potential, role in the competition for innovation etc. – may explain why the widely predicted regulatory "race to the bottom" did not take place. It should be noted in this context that countries with stricter environmental policies on average are more competitive than others (Esty et al. 2006, Jänicke/Jacob 2006). New findings indicate that countries with innovative environmental technologies prove successful in total factor productivity (the efficiency of production on given capital and labour inputs) and therefore in economic growth (Allianz 2008, 33).

2.2 Structure of the Environmental Industry

The „Environmental Industry" (EI, see box 1) has no clear statistical status and is not part of the traditional sectoral system. It has a statistically defined core and a more open marginal area. A certain sectoral identity however can be discerned not only by the kind of output but also by certain sectorally specific activities (e.g. collective lobby activities). For a long time EI was defined as the sum of producers of "end-of-pipe"- technology typically adding clean-up measures to "dirty technologies" (including related services). Instead, EI is now defined by two different functions:

1. Pollution Management: *„...sectors that manage material streams from processes (the techno-sphere) to nature... typically using ‚end of pipe' technology".*

2. Resource Management: *„sectors that take a more preventive approach to managing material streams from nature to techno-sphere" (Ernst & Young 2006).*

In a broad empirical study Ernst & Young described the EU-25 EI as a sector with a turnover of 227 bn. € or 2.2% of the GDP (2004), while the figure for EU-15 is only slightly lower: 214.000 €. (Ernst & Young 2006). If estimations are included – though they are still incomplete - the total turnover is et least 270 bn.€ or 2,6% of the EU-25 GDP (2004) (see Table 1). The EU-25 „full-time job equivalents" are 3,4 million. Germany, France and UK have the largest EI and the highest contribution to foreign trade within the EU (Ernst & Young 2006, see also DTI/DEFRA 2006 and GHK, Cambridge Econometrics, IEEP 2007). According to Roland Berger the size of the German EI (defined as "GreenTech") was 4% of the GDP in 2005 (BMU/ Berger 2006), according to Ernst & Young (2006, 28) it was 3% in 2004. The German Institute for Economic Research (DIW) counted nearly 1,8 million employees in the EI, after a steady increase (UBA 2008). A study of Austria revealed similar results about the size and dynamics of their EI (Köppl 2006).

Table 1: Eco-Industry Turnover EU 25, Germany, UK 2004 (bn. €)

	EU 25	Germany	UK
A) Pollution Management:	82,0	26,5	4,7
• Waste Water Treatment	52,2	19,3	1,6
• Air Pollution Control	15,9	4,5	1,7
• Remediation / Clean Up of Soil / Groundwater	5,2	1,1	0,3
• Noise & Vibration Control	2,0	0,4	0,1
• Environmental Monitoring / Instrumentation	1 [2)]		
• Nature Protection [1)]	5,7	1,2	1,0
B) Resource Management:	168,5	75,3	14,8
• Solid Waste Management & Recycling [1)]	52,4	14,9	6,4
• Recycled Materials	24,3	6,8	3,5
• Renewable Energy Production	6,1	2,2	0,4 [2)]
• Water Supply	45,7	11,4	4,5
• Eco-construction (estimated)	>40 [2)]	40 (2005) [2)]	
C) Administration, Management, Research [1)]	19,8	4,4	2,0
• General Public Administration	11,5	4,4	1,6
• Private Environmental Management	5,8		0,4
• Environmental Research & Development	2,5 [2)]		
	> 270,3	> 106,2	>21,5

Source: Ernst & Young 2006. Own compilation.
1) revised classification,
2) estimations (not included in the total amount of the study) in brackets.

Besides the existing problems of statistical classification of the environmental industry, the main difficulty is to define a significant environmental improvement.[3] Which kind of cars or buildings is energy efficient enough to be included? This blurring seems to have caused some underestimation of the size of this "sector". Even the remarkable study of Ernst & Young shows this underestimation. Their turnover figure for the British EI is 21,5 bn. € (2004). DTI/DEFRA have a significantly higher figure of 35 bn. € in 2005 (DTI/DEFRA 2006). The figure of the annual turnover of the German EI is 66,2 bn. € (Ernst & Young 2006). Roland Berger however has a remarkably higher figure of 150 bn. € in the year 2005 (BMU 2007). Some relevant environmental friendly technologies and services are not included in the Ernst & Young calculation, e.g. eco-construction, the EU-wide turnover of which the authors estimated at 40 bn. €[4]. The figure for renewable energy is by far too low, for Germany it is not 2,2 bn. € but 12,3 bn. € (in 2004), even higher than the EU figure (6,1 bn. €). Eco-tourism or "green" financing (e.g. in Germany the public "Kreditanstalt für Wiederaufbau" (KfW) or the influential semi-public Deutsche Bundesstiftung Umwelt) are not included as well (Ernst & Young 2006). Bio-products or other specified environmentally friendly products (e.g. energy-efficient „Top Runner"-products) are not visibly accounted for in the statistics. This leads to underestimation. The inclusion of just "eco-construction" would increase the weight of the EI to 2,6% of the EU-25 GDP. However, the growth of eco-efficient technologies seems to be rather high especially in some fields where operationalized definitions are difficult or so far lacking.

The problem of underestimation becomes clear if we take a recent study on the investment in German climate policy into account. It shows, that the investment in climate protection alone amounts to 95 bn. € or 5% of the GDP (2005). If the recent additional policy package is included, 30 bn. € or 1,5% of GDP must be added. The resulting energy saving effect, by the way, results in a net surplus of several billion € (Jochem/Jaeger et al. 2008, see also UBA 2007, McKinsey 2007).

Table 1 shows the different parts of the EI according to the classification of Ernst & Young and their EU-25 turnover in 2004. The available figures for Germany and the UK are added. The classification has been revised as follows: "Solid waste management and recycling" has been added to the "resource management" part and "nature protection" to the traditional pollution management" part (both seems to be highly plausible). Estimates of turnover have been added where available (and mentioned in the EU study). Administration, management and research have been taken into a separate class, because they have to

3 In terms of environmental *quality.* Relating to environmental pressure, some correlations could be identified, see Miltner 2008.

4 This is now equivalent to the German investment in energy-efficient buildings in 2005 (Jochem/ Jaeger et.al. 2008).

do with both the pollution management and resource management (before they were included in the clean-up sector). Finally, additional parts of "environmental industry" are mentioned, which are not (or not fully) included in the calculation of Ernst & Young.

This makes clear that:

- The environmental industry has two faces: traditional pollution control and resource management, the latter being the larger part if we use a more plausible systematic classification, putting e.g. waste management and recycling in the resource management part. Also a recent study on seven OECD countries using a similar dual classification comes to the conclusion that "cleaner production" today has a larger market share than the "end-of-pipe" sub-group (Frondel et al. 2007, see also DTI/DEFRA 2006).
- The total calculable turnover of the EU-25 EI is clearly higher than the study shows (at least 270 bn. € instead of 227 bn €). Figures for renewable energy, for example, are too low, others are not included. The EI is larger if sub-groups are included which are less "visible" in terms of statistics.
- Taking this into account it is highly probable that the EU-25 EI (2004) is a remarkable industry of not less than 2.6% of the GNP.
- There is however a relevant part left if eco-efficiency is becoming a general trend for the whole industry and within enterprises. A general mainstreaming of eco-efficiency could finally make the search for a special environmental industry obsolete.
- Within the new defined environmental industry it is the part of resource efficient (not end-of-pipe) technologies which is characterised by high growth.

2.3 Dynamic: Environmental Industry, a fast Growing Sector

The real growth of the European EI between 1999 and 2004 was 7% (Ernst & Young 2006). Parts of the EI have a much higher growth. According to Roland Berger the annual real growth of the German EI could be about 8% up to 2030. The turnover of this "sector" was 150 € bn. in 2005. His estimated share of GDP was 4% and could rise to 16% or € 1.000 bn. in 2030 (BMU/ Roland Berger 2007). In the UK the EI increased – partly due to the inclusion of new statistical subclasses (see Table 2) – from 15 bn. BP in 2000 to 24 bn. BP in 2005 (35,3 bn. €). UK average annual growth between 2000-05 was about 7%.

Table 2: Turnover (million £) and employment in the eco-industry in the UK

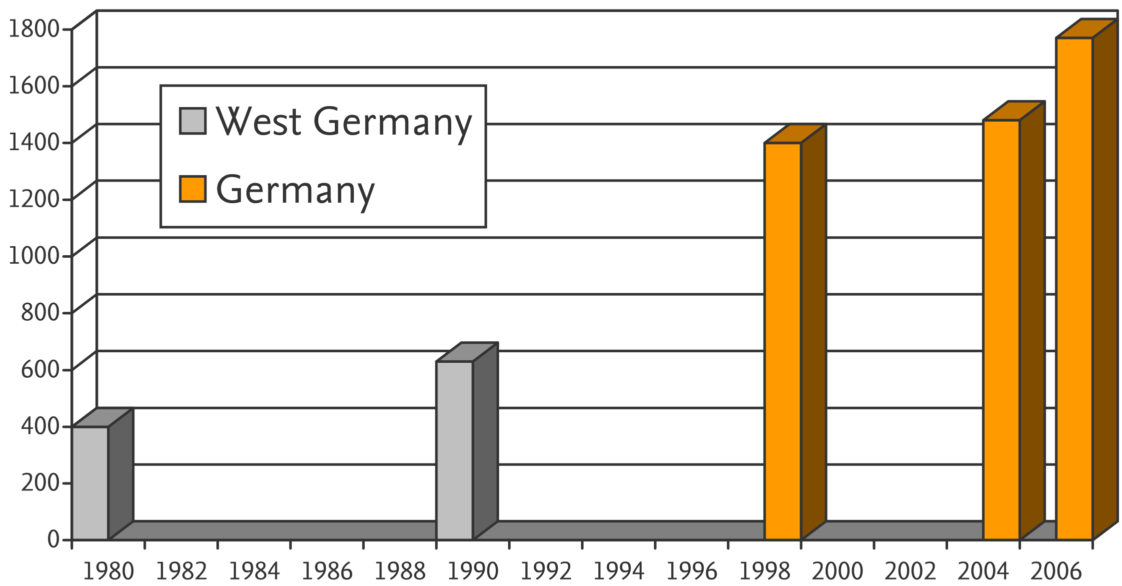
Sector	2000*	2005**
Water & wastewater treatment	7334	9400
Waste management	4600	8100
Env. consultancy services	600	1230
Air pollution control	907	583
Other	523	523
Contaminated land remediation	638	494
Cleaner technology & processes		177
Noise & vibration control	77	369
Renewable energy	200	290
Env. monitoring & instrument.	100	189
Marine pollution control		22
Research & development		
Energy management		2648
Total	**14979**	**24025**

Sector	2004**
Water industry	**50,000**
provision of services	28,000
sewage	22,000
Waste management	**69,000**
collection	52,000
recycling	17,000
Renewable energy	**6,370**

* Source: 'Global Environmental Markets and the UK Environmental Industry', DTI and DEFRA 2002
** Source: 'Emerging markets in the environmental sector', UKCEED for DTI and DEFRA 2006

The slow growth of the employment in the German EI in recent years due in large part to the fact that the calculation relies mainly on traditional and in the meanwhile slow growing end-of-pipe technologies (see Figure 1).

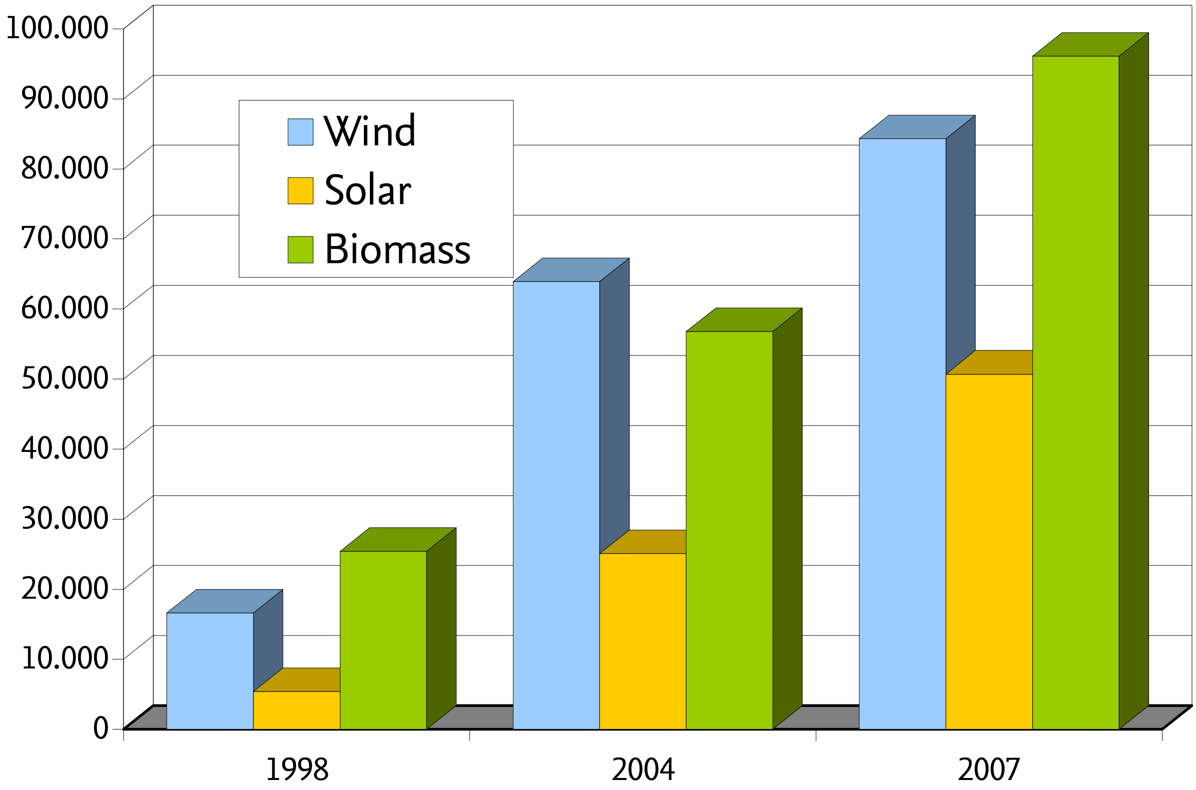
Figure 1: Employment in the German Environmental Industry (in 1000)



Source: Own compilation; BMU 2008

The growth of employment in the sector of eco-efficient technologies ("Green-Tech") is significantly higher, renewable energy having the highest growth rates (Figure 2). In 2007 the sector provided 249.000 jobs (in 2004: 160.000, BMU 2008).

Figure 2: Employment in the German Renewable Energy Sector 1998-2007



Source: BMU 2008

A survey of 1 500 German firms producing environmental technology and services provided the following picture (Table 3) of this industry, here being titled as „GreenTech“ industry:

Table 3: Structure and Growth of the German „GreenTech“ Industry

	German Share of GreenTech World market	Annual Turnover Growth 2004-2006	Expected Annual Turnover Growth 2007-09
Environmental friendly energy supply	30 %	30 %	27 %
Energy efficiency	10 %	21 %	22 %
Material efficiency	5 %	11 %	17 %
Recycling	25 %	13 %	11 %
Sustainable water supply	5 %	12 %	15 %
Sustainable mobility	20 %	29 %	20 %

Source: BMU 2007, p. 3 and 14 (Roland Berger)

Again the high importance of the special resource management part becomes visible. The growth dynamics here are especially high. In Germany it is clearly higher than the growth of the pollution sector, which is confronted with *decreased domestic demand* and is successful only as an export sector. We can plausibly assume that the growth of the resource management sector is higher also in other highly developed countries where domestic markets for clean-up technologies tend to stabilise (or even decrease). The world market of resource-efficient technologies is rapidly expanding. As companies often benefit directly from the cost-saving potential of production-integrated environmental technologies, related innovations are set to gain enormously in importance worldwide (Allianz 2008, 30). Germany – together with other European countries and especially the U.K. – here has a strong export position (see ADAME 2007).

A significant additional driving factor seems to be the volatile prices of resources: A survey of German companies on the strategic relevance of aspects due to the 'Global Change' revealed that more than 80% of the companies fear resource scarcity (Biebeler et.al. 2008, 14-26).

Table 4: Annual Growth Rates of Selected Eco-efficient Technologies in Germany 2005-2007

• PV:	50 %
• Heat pumps:	44 % (2005/6)
• Biogas power:	37 %
• Bio diesel:	21,6 % (2005/6)
• Wind energy:	19 %
• Passive houses:	19 %
• Bio Food:	15-16 %
• Contracting:	about 15 %

Source: Own compilation, BEE, KfW, BMU 2008

The high growth of resource management technologies and the different growth of pollution control is highlighted if we take a snapshot of the present real turnover growth of selected eco-efficient technology in Germany (Table 4). This has to be compared with the constant demand for pollution control technology: The public, private and expenditures of privatized public companies for pollution control together remained stable in Germany between 1994 and 2004 (33,9 m. € compared to 34,4 m. €, Statistisches Bundesamt 2007, 15).

Table 5: Global Annual Growth of selected Environmental Technologies

• PV (grid-connected capacity, 2005-07):	49 %
• Investment in renewable energies (2005-07):	32 %
• Wind energy (capacity) (2005-07):	26 %
Expected:	
• Bio plastics (forecast 2005-20):	22 %
• Hybrid cars (- 2020):	22 %
• Bio diesel (- 2020):	20 %
• Automatic waste separation (- 2020):	15 %
• Decentral water management (- 2020):	15 %

Source: Roland Berger 2007, REN21 2007

Energy-efficient measures and innovations will therefore gain the position of a *key strategy* for sustainable growth in Europe: A cross-sectional analysis of economic performance in 15 EU-countries points out: Investing in more productive and hence more economic use of energy is a driving factor for economic growth (Allianz 2008,31). Calculations on the return of investment on a global scale have shown, that - with an average internal rate of return of 17 % - the annual investment of 170 billion $ could result in savings of up to 900 billion $ annually by 2020 (McKinsey Global Institute 2008,.7-8). In addition the costs for otherwise presumably required new power plants could be avoided. (At a micro-economic level however energy-efficient investments will bear costs as well as benefits, depending on the sector, company or policy instrument, see also Jochem/Jaeger et al. 2008, 27).

3 Governance

In the following section we analyse the relationship between regulation and the growth of the Eco-industry. After a general introduction we will look at four selected best practice cases regarding environmental policy, growth and innovation.

"Compliance with policy objectives and legal requirements set by EU and national authorities will be the main drivers of eco-industry growth in the near future" (Ernst & Young 2006, p. 48). If this is true, then the question of governance arises. In a recent publication we have argued (Jänicke 2008), that an environmental innovation is best supported under the following conditions:

- clear, demanding and calculable goals
- hybrid instrumentation: economic instruments (like eco tax reforms and/or emission trading) to stimulate a *general tendency* ("Tendenzsteuerung") and

specific "detail regulation" ("Fine-tuning", "Detailsteuerung") to use specific innovation potentials which otherwise will not be fully mobilised
- a policy mix supporting all phases of the innovation process and providing additional supporting instruments (e.g. labelling or networking of all kinds).

Therefore financial instruments like environmental tax reform (ETR), together with specific regulation (e.g. the Japanese Top-Runner-Programme), is regarded as the most effective approach for environmental innovations. Ekins and Venn (2006) have shown the importance of both instruments in a comparative study. Not least the technological effects of high energy prices in the 1970s and today have confirmed the significant role of the price mechanism. However, it is not easy to find data reliable enough to prove the plausible relationship between changes in relative prices and the growth of EI in general. Again it is the two faces of EI that create the difficulty.

Therefore, the differentiation between pollution management and resource management becomes essential. As mentioned above there is no plausible positive relationship between resource prices or taxes and the growth of traditional clean-up technologies. However, the correlation between resource prices and resource management (or eco efficiency) is highly plausible.

Changes in (relative) resource prices can be effected both by market mechanisms and by government intervention. Government intervention can function as positive incentive (subsidies, or feed-in tariffs) or as negative incentive (taxes, emission trade). Positive incentives give support to a specific innovation. Negative incentives like taxes create economic pressure for innovation in a certain field of technology. Their advantage is the openness of the field of innovation and the public revenue. But both kinds of intervention change the relative prices, which has steering effects. In our context we focus on the steering effect of changing relative prices, irrespective of their causes (positive/negative government intervention, market mechanism). This is necessary because the steering (and innovation) effect of, for example, the rising price of oil cannot be ignored.

However, rising oil (or raw material) prices are not specific for Germany. Therefore they cannot explain the differences of the chosen case of best practice. A country study therefore seems legitimate.

In the following part we illustrate the broad spectrum of influences supporting eco-efficient innovation and the growth in the eco-industry. Policy regulation and a price mechanism are clearly essential. But the policy mix is different from case to case.

4 Successful Eco-efficient Innovation: Four Cases (Germany)

Four selected best practice cases of eco-efficient innovation in Germany will be sketched in this section to illustrate the win-win potential and the role of policy intervention. We will look at the policy-mix and the price mechanism but also at the outcomes and impacts – the potential co-benefits - of ambitious environmental policy measures. The German eco tax has contributed to innovation and growth in the field of *(1) low-energy buildings* and *(2) fuel-efficient diesel cars* (Jacob et al. 2005). In both cases additional supporting instruments came into effect: Energy minimum performance standards for buildings together with subsidies for energy-saving investments and a tax differentiation for new fuel-efficient cars were additional instruments in the policy mix. *(3) Recycling* is dominated by regulation but in the case of industrial recycling the rapid increase of material prices has also stimulated more efficient solutions. Finally we describe the case of *(4) renewable energies*, where financial mechanisms – here subsidies as feed-in-tariffs – have caused a rapid modernisation. Again, a policy mix with additional instruments was relevant. We also will have a look at factors like export, job creation and of course the environmental impacts (see Table 6).

Table 6: Eco-Industry: Four German Success Stories

	Fuel-efficient Diesel Cars	*Low-Energy Buildings*	*Recycling*	*Renewable Energies*
Taxes / Price Mechanism	Car Tax, Eco Tax, Oil Price	Eco Tax Oil Price	Raw Material Prices	Oil Price
Other dominant instruments		Standards, Subsidies	Regulation	Feed-in Tariffs, Subsidies
Growth	++	+	++	++
Employment		+		++
Innovation	+	+	++	++
Export	++	+	++	++
Environmental Impacts	+	++	+	++

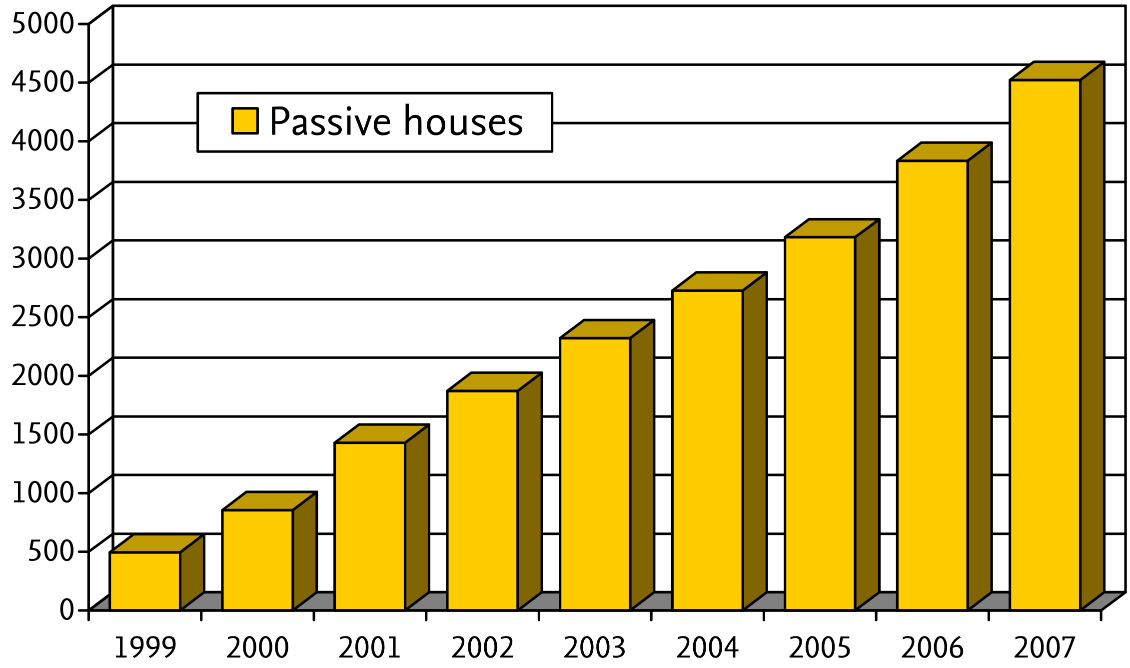
Source: Jänicke 2007. Judgement: + = above average, ++ = far above average

4.1 Low-Energy Buildings

A policy to improve the energy efficiency of buildings was part of the climate programme of the red-green coalition government beginning in 1998. The effect of this policy was a reduction in heating energy use in Germany by about 20% between 1996 and 2005 (SRU 2008). The policy mix included energy efficiency standards (insulation, heating system) together with financial mechanisms. Most prominent was the eco tax (1999) and a market incentive programme. Support for low energy houses was a special activity of the state-owned bank Kreditanstalt für Wiederaufbau (KfW). In the case of Diesel cars the oil price was unimportant in the first years, but later on it was a strong factor.

There has been a rapidly expanding market for low energy houses in Germany after 1999. More than 14.000 very low-energy houses (27.000 flats, <4 l/ oil/m^2) have been supported by the KfW between 1999 and 2007. The annual growth rate was above 30%, the sub-group of passive-energy houses (<1,5 l oil/m^2) amounted more than 4.200 (6.300 flats) in 2007 (Figure 3). The cost difference compared with a normal house is only 8% (KfW 2007, BMU 2007, 59ff.). The subsidy has been increased in 2007, together with tightening of the efficiency standard by 30% (which after 2012 shall be strengthened again by 30%).The present energy standard (2002) is about 7 l oil/m^2 for single houses. The average energy consumption of older houses in Germany is 25 l oil/m^2 (BMU 2007).

Figure 3: Passive Houses in Germany



Source: Kreditanstalt für Wiederaufbau 2007

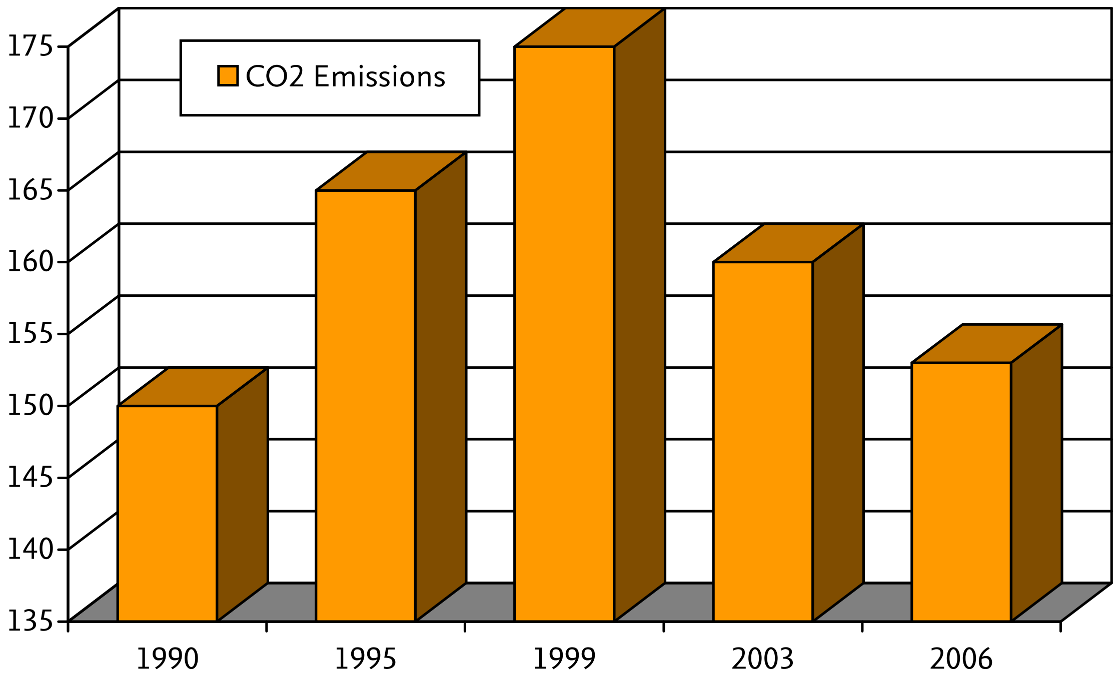
As mentioned above, the investment in energy-efficient buildings in Germany amounted to 40 bn. € in 2005. The construction industry – after a long recession – in 2008 noticed a new revival mainly due to the new energy and climate policy (Keitel 2008). The market for special components of low energy houses (e.g. insulation materials) is rapidly increasing. The market for heat pumps was similarly dynamic (a 44% increase in 2006). Germany also has by far the highest proportion of low energy houses, often pre-fabricated. Since the EU commission envisages the low energy house standard for 2015, this may be at least a good start. In the meantime (2008) the EU commission envisages a CO_2-reduction for Germany in the housing and construction sector of 14% by the year 2020.

4.2 Fuel-efficient Diesel Cars

The following case is also an illustration of the difficulty to draw a clear demarcation between EI and the rest of the economy. But cars with a fuel efficiency double that of the existing car fleet may be worth consideration in our context.

Diesel cars with a fuel consumption of 3 or 5 l/100 km came on the market in Germany in 1999 following a differentiation in the car tax which had been introduced in 1997. It explicitly supported fuel-efficient cars with a high tax bonus. This was a de facto bonus for Diesel (according to an earlier agreement between state governments and the German car industry). Only Diesel cars with fuel injection achieved the supported performance level. Paradoxically, the success of the most energy-efficient 3-liter Diesel cars (Volkswagen) was limited but the regulation of 1997 coincided successfully with the introduction of the eco tax by the red-green government. The eco tax was introduced in 1999 and added to the mineral oil tax which had already been strongly increased in the early 1990s. This led to a successive reorientation of German car drivers in other segments of the car fleet as well. The result was not only a market success of fuel-efficient Diesel cars (already having strong market position in Germany) but a general decrease of fuel consumption since 1999 (shortly after the start of the red-green government) which also influenced the CO_2 emissions of cars in general (see Figure 4).

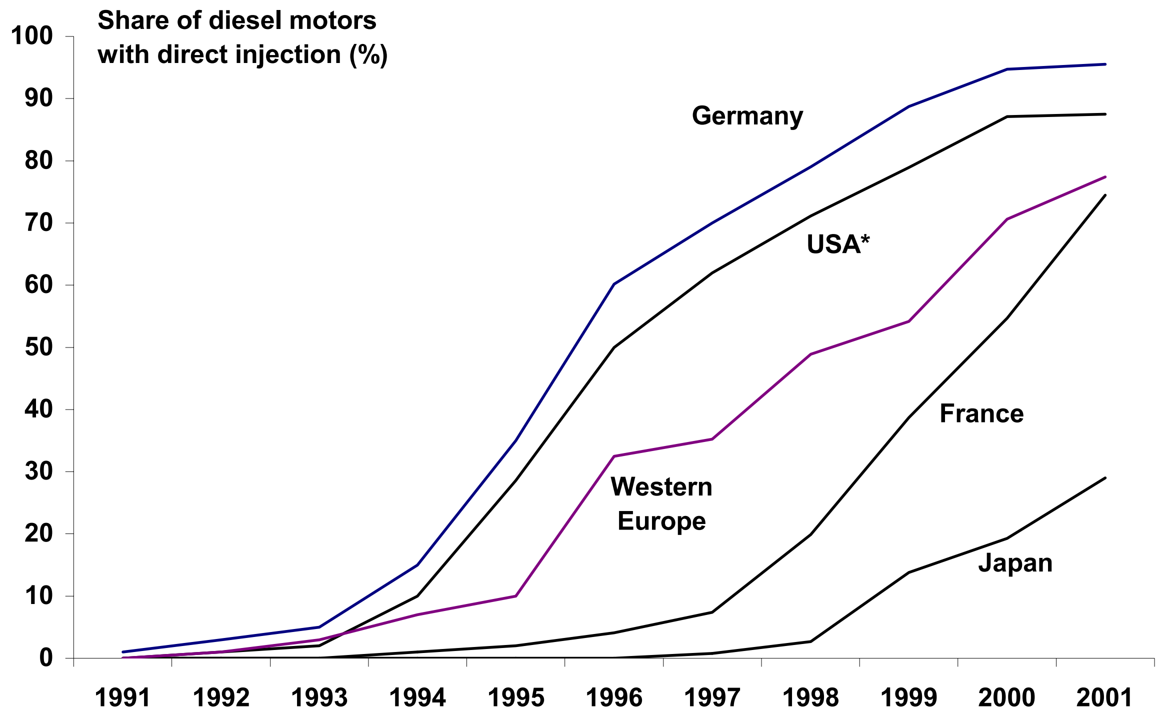
Figure 4: CO_2 Emissions of Car Traffic in Germany 1990-2006 (in g/km)



Source: SRU 2005, 63, Statistisches Bundesamt

The effect of both economic instruments was already visible before the oil price increased. Therefore the improved eco-efficiency can be explained to a high degree with the policy intervention, though the later effect of the oil price cannot be ignored.

Figure 5: Market Shares of Fuel-Efficient Diesel Cars



Source: Jabob et al. 2005, p. 34

The economic result was a clear world market success of German Diesel cars, Germany here being the lead-market with the US market as early follower (Figure 5).

It is interesting that this economic approach has been even more successfull in reducing CO_2 emissions if compared to the regulation-oriented policy of Japan: In July 2007 the Ministry of Economy, Trade and Industry, and the Ministry of Land, Infrastructure and Transport promulgated Japan's New Fuel Economy Standards for cars, as a part of the Law Concerning the Rational Use of Energy. Car producers are required to improve fuel efficiency, the new Top Runner Standard Values mean 16,8 kilometers per litre for cars by fiscal year 2015. (This is close to the 120 g/km target of the EU for 2012).

4.3 Recycling

The strategic economic role of recycling for sustainable growth is widely acknowledged. But so far policy success has been limited. Changes in modern economies will however underpin the worth of recycling:

45% of all production costs for German industry are due to costs of materials. This share has even increased. Labour costs on the other hand account for less than 20%. That means energy and raw materials which are included in waste will become a forgotten resource.

In times of rising resource prices these sunk costs could also reach a *new* market price. It will be of basic interest for a society to substitute new energy and raw materials. Additionally, in times of rising CO_2-costs as induced by the EU-Emission Trading System, energy and material intensive industries in particular will have problems sustaining their competitiveness. Using recycled metal for example could cut emissions by four-fifths.

Recycling is therefore essential to *resource efficiency:* Resource productivity as a strategy to minimize the transformation of products from the natural system to the industrial system is accompanied by a strategy to minimize material flows from the sphere of production and consumption to nature.

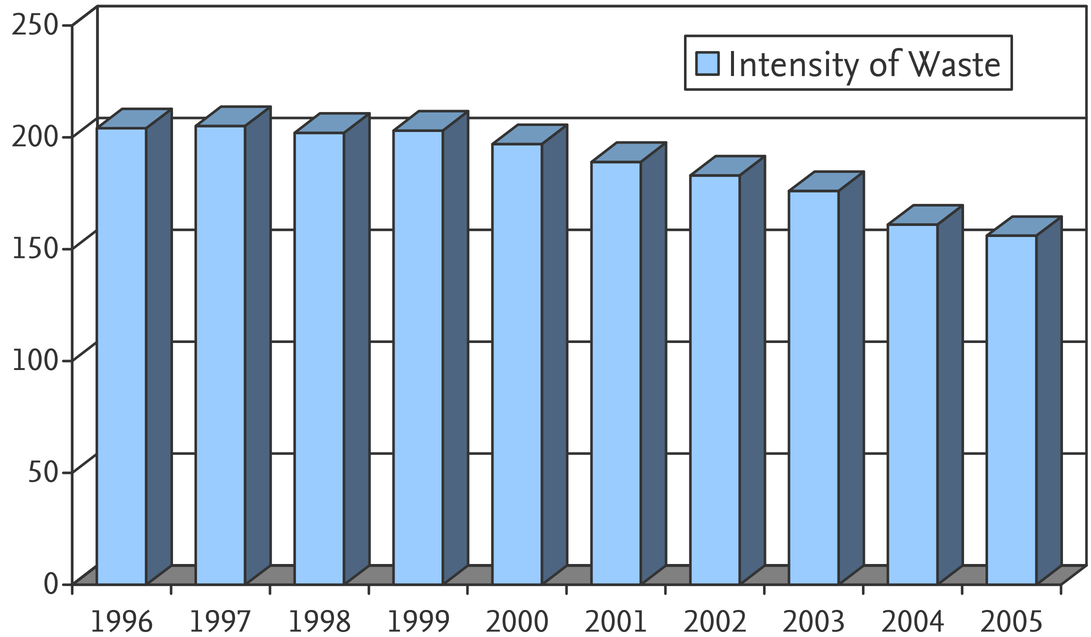
In 1994, Germany introduced an ambitious recycling policy, which was strengthened in 2001 by a regulation which included a target to prevent any landfill without pre-treatment up to 2005. This was essentially a regulatory policy (a successful voluntary agreement of the construction industry being the exception). Töller (2007) in an examination of steering modes in German waste policies during the last 15 years, concludes that a perhaps supposed "withdrawal of the state", symbolised by deregulation, privatisation, or an increased intensity of societal self-regulation can not be witnessed in the case of German waste policies.

The German sustainable development strategy also formulated a target to increase the resource productivity by 100% between 1994 and 2020.

The policy caused an increase of recycling rates together with heat recovery from incineration, and it reduced the rate of final disposal to landfill from 63,5 mt. in the year 1998 to 45,7 mt. in 2005 (Statistisches Bundesamt 2007, 7). This also had a positive effect on the waste intensity of the economy (Figure 6). There was a clear decoupling of GNP-growth and waste generation beginning in 2000. The total waste generation in 2005 (332 mt.) was nearly 14% lower than in 1996 (385 mt.) (BMU 2007, 95f.). The second environmental benefit is a reduction of greenhouse gas emissions. According to the German ministry of environment 40 mt. CO_2-equivalents have been avoided by waste management, mainly by closing down land-fill deposition sites (compared with 1990; BMU 2006, 37).

One reason for the trend mentioned is the decrease of construction waste due to the stagnation of the German economy after 2001. The advanced waste management policy (e.g. the phasing-out of landfill without pre-treatment), however, seems to have been the dominant cause. The third most relevant factor for the future is presumably the change in commodity prices in the last years (BGR/DESTATIS/UBA 2007, 17), especially the increase of economically important metals and materials.

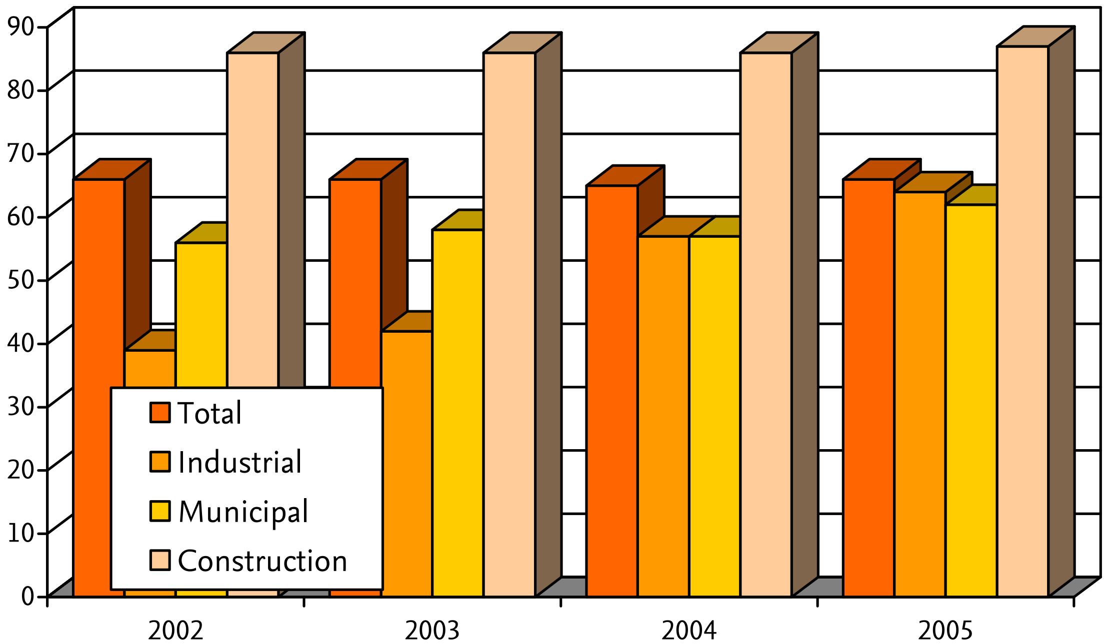
Figure 6: Germany: Intensity of waste generation 1996-2005 (kg/ 1000 € GDP)



Source: Statistisches Bundesamt 2006, 2007

Figure 7 shows a remarkable increase in the recycling rate of industrial waste in the last few years parallel to the rapid increase of raw material prices (2000-05: +80%, BMU 2007). The difference between industrial and municipal, or construction waste is also remarkable. The most plausible explanation is the immediate pressure of raw material prices on the industry as a hard cost factor. The price signal seems much less visible and relevant for the other sectors.

Figure 7: Recycling Rates in Germany 2002-2005 (in %)

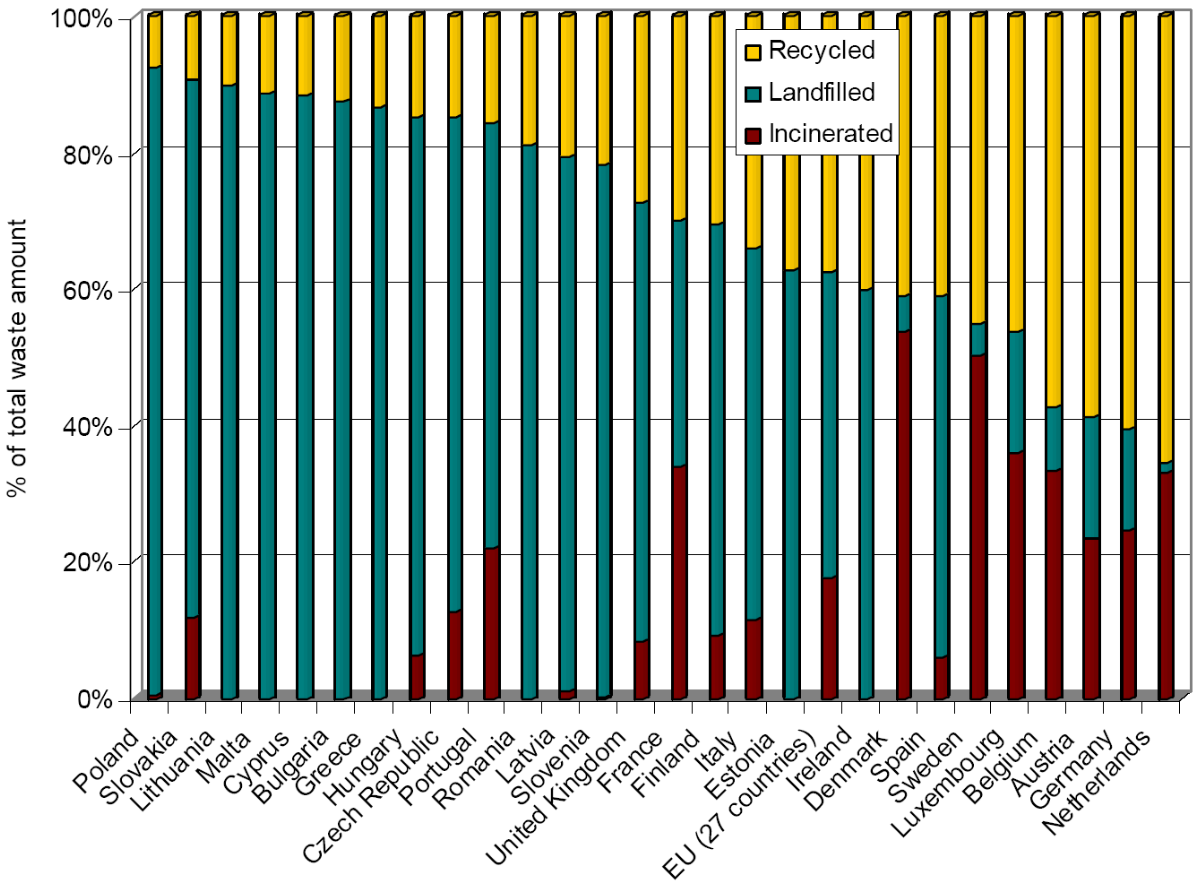


Source (Data): Statistisches Bundesamt 2007

Compared with UK (and most other EU member states) the German regulation caused a significant higher share of recycled or incinerated waste and consequently a significantly lower proportion of waste deposited in landfills. Regarding municipal waste this is shown in Figure 8.

The price mechanism - as an additional steering factor - becomes visible in the last years as regards industrial waste.

Figure 8: Municipal Waste in EU Countries: Recycling, Incineration and final Deposition



Source: Sander 2008, p.8 / following EUROSTAT 2007

The economic co-benefit of this policy was a rapid growth and an increased employment in the waste industry and the recycling sector. The ministry of environment calculates a turnover of the waste industry of about 50 bn. € and an employment effect of about 250.000 jobs. In addition there was an annual saving of raw material imports of about 3,7 bn. €.[5] The special recycling sector reached an annual growth of turnover of 13% between 2004 and 2006 (employment: 9%)

[5] Also the German Institut der Deutschen Wirtschaft (Biebeler/Mahammadzadeh/Selke 2008; Barth 2006) underpins the rising economic importance of re-use and recycling of raw materials.

and is expected to grow by 11% between 2007 and 2009 (employment: 7%) (BMU 2007, 15, 95-97). German recycling technologies have a 25% of the global market. The share of automatic separation technologies – a fast growing market – is 64% (ibid. 13, 105).

Statistics from DEFRA also show a high growth of the British waste management sector from 6,8 bn. € (2000) to 11,9 bn. € (2005). The employment figure is 69.000, including 17.000 jobs in the recycling sector. The share of landfilled municipal waste is higher in UK, and the proportion of recycling or incineration with heat recovery is lower than in Germany.

4.4 Green Power

An ambitious regulation to stimulate renewable energy in the German power sector was introduced by the red-green coalition government (1998). This policy was very effective and has caused a rapid increase in renewable electricity: The original target of 12,5% share of electricity in 2010 has already been achieved in 2007 (about 14,2%). A new target was fixed in 2007: 25 - 30% in 2020 instead of more than 20%.

The main instrument - changing the relative prices of green power - has been the feed-in-tariffs which already existed in the 1990s (Electricity Feed In Act 1990) but have been significantly increased and broadened in 1998 by the Renewable Energy Resources Act (EEG). This meant attractive prices and obligatory feed-in for renewable electricity. In 2005 total fees achieved an amount of 4,19 bn. € (3% additional electricity costs for households, BMU 2006, 2007). This instrument has been broadly adopted in other countries (Reiche 2005, Mez 2008).

The second instrument – again financial incentives – was support for investments by the "Market Incentive Programme" 2000-04: support for investment (about 665,4 mill. €). Again the public bank Kreditanstalt für Wiederaufbau played an important role. Financial incentives for alternative heating in buildings will rise to 350 mill. € in 2008 and up to 500 mill. In the year 2009. The role of rising oil prices cannot be ignored but there is no strong correlation with the investment in renewable power.

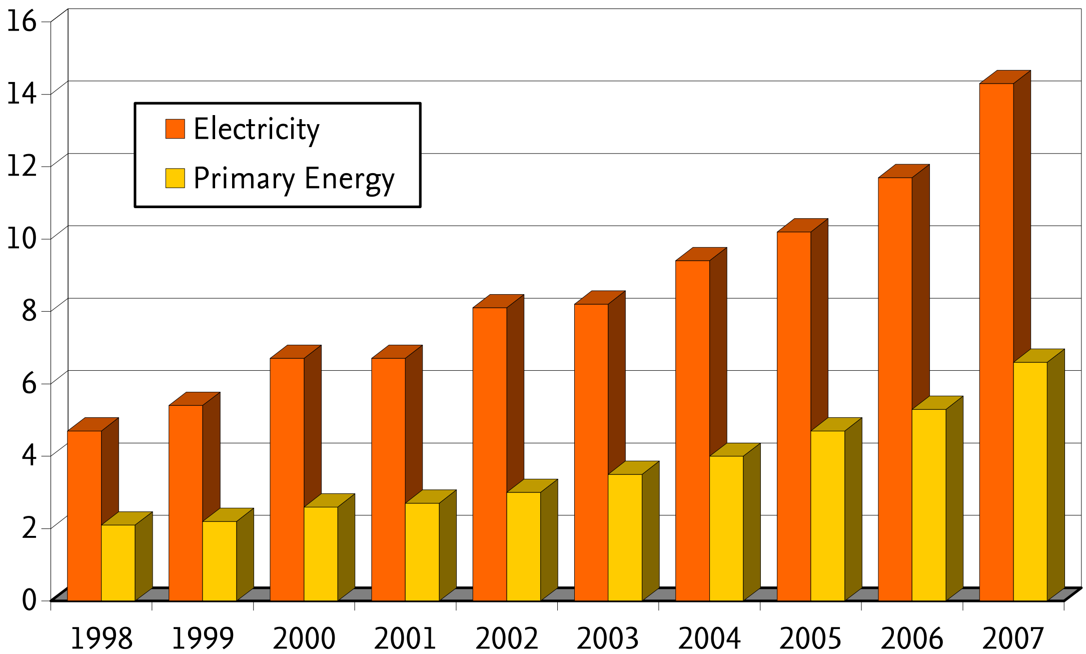
The increase in renewable power was remarkable. While from 1991 to 2001 there was a doubling of green power production (from 19 to 37 TWh/a), the next doubling took place only within five years (2006: 73, 2007: 86,7 TWh/a), again with a slight speeding-up in the last years.

The Environmental benefit of this policy was important: 58 mt. CO_2 emissions have been avoided in 2007, 14 mt. more than in 2006 (BEE 2008). No other instrument of the Germany climate policy is more effective (BMU 2007). There is of course also a positive impact on air pollution. In addition, external costs of some 8,6 bn. € for the fiscal year 2007 could be avoided.

The *Economic impact* may have been the most important*:* In 2007 the turnover over the green power sector was: 25 bn. € (2004: 12,3 bn. €). The direct and indirect employment effect (2007) was 250.000 jobs. The forecast for 2020 (400.000) may already be too pessimistic (BMU 2007, 2008).

The additional costs per kWh of the feed-in tariffs (to be paid by the grid, i.e. by all households) was one cent in 2007 (1,5 cent in 2020). In 2008 the existing rate of lowering of the feed-in tariffs was revised; it is now 8-10 cents lower each year for PV. This subsidy as such could be viewed as an investment into the first-mover advantage of a strong export position for Germany in PV and wind energy. It could also be seen as a public investment in a remarkable innovation process: Immediately after 1998 a rapid increase of inventions (patents) in the area of renewable energy could be observed in Germany (OECD 2005). The global market share of Germany for biogas technologies is 65%, for PV 41% and for wind energy 24% (BMU 2007, 41).

Figure 9: Share of Renewable Energy in Germany 1998-2007 (per cent)



Source: BMU / BEE 2008

The structure of the renewable energy industry will change rapidly, when current dynamics relating to innovation processes and 'economies of scale' go on: Expert estimations anticipate that in 2010 in South Germany the reduction of production costs of solar energy will reach the level of 0,15 € per kwh (or in California 0,11 € and in Spain about 0,10 € per kwh). In this case solar energy will reach *'grid parity'* and will be fully competitive with coal-fired power plants, especially if accompanied by a realistic price scheme of CO_2-emission trading. The market for the production of solar energy plants seems to be 'unlimited'.

5 Conclusions

Regarding the structure, function and dynamics of the environmental industry we come to the following conclusions:

- The environmental industry is a remarkable, fast growing "sector" of the European industry. It has been underestimated because there is an inherent statistical boundary problem and the picture is incomplete. Even the best European study of Ernst & Young (2006) on EI clearly underestimates the total calculable turnover of the EU-25 EI (at least 2,6 instead of 2.2 % of GDP). Figures for renewables are too low, and others are not included due to insufficient data. But the German investment caused by climate policy alone amounts to 5% of the GDP (2005). The EI is also larger if specified sub-groups are included which are less "visible" in terms of statistics. It would be largest if the present mainstreaming of eco efficiency within enterprises could be taken into account in terms of statistics.
- The environmental industry essentially has two faces: traditional pollution control and resource management, the latter being the larger part if we use a more plausible classification (e.g. including waste management/recycling into the resource management part). Resource management is also characterised by high growth. The demand for pollution control technologies on the other hand is rather stagnating in advanced European economies like Germany.
- Pollution control or end-of-pipe treatment has its stable function in the process of industrial growth and remains a field of possible innovation (e.g. membrane technology or CCS). But as a rule it has no positive effect on resource productivity (often the contrary is true), whereas resource management is central for resource productivity and sustainable growth. Therefore it makes sense to differentiate both sub-classes of the EI more systematically.

To get a better picture of the dynamics within the resource management part of the EI we have used the German case, being the most advanced case in Europe. This made it also easier to exclude the influence of resource prices which is a general factor compared with the specific factors of the German case. We have focused on four success stories regarding environmental and climate policy: low-energy houses, fuel-efficient Diesel cars, industrial recycling and renewable energy. They at least illustrate the large potential of resource efficient innovation affected by ambitious environmental policy measures. In this way they can be cautiously interpreted as follows:

- There is multiple win-win potential for technology-based environmental policy. The four cases show the economic co-benefits of innovation, growth, successful export and employment (the net job effect may give a different but not a contradicting picture). The advantage of increased resource productivity it is implicit in the selection of our cases.

- Strict and calculable environmental policy measures can stimulate innovation. In the cases of energy-efficient buildings and renewable energy it stimulated clearly the feed-back of the innovation cycle from diffusion to invention. This would mean that a strict environmental policy can also enlarge the technical potential and the available options.
- Government intervention was essential, generally through a policy mix of different instruments. The combination of the price mechanism and regulation was crucial. The change of relative prices – whether by taxes, subsidies or the market – had a dominant influence. Taxation was a strong driver in the first two cases (fuel-efficient cars and buildings). Regulation was important in the case of recycling, but the role of the price mechanism was visible in the case of industrial waste management as well.
- Sustainable growth in our cases was not only policy-driven but also depended on an innovative type of industry, the resource management sector of the environmental industry.

Changes of relative prices – together with regulation - had clear steering effects notwithstanding their causes: taxes, subsidies, or market dynamics. However, it makes a distributional difference whether the price difference creates income in OPEC countries or in the national public budget. Therefore ETR in principle is the better solution. Though subsidies (including feed-in tariffs) have proven important as specific market support for certain technologies, ETR together with regulation seems the best general mechanism to stimulate a broader range of innovations.

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